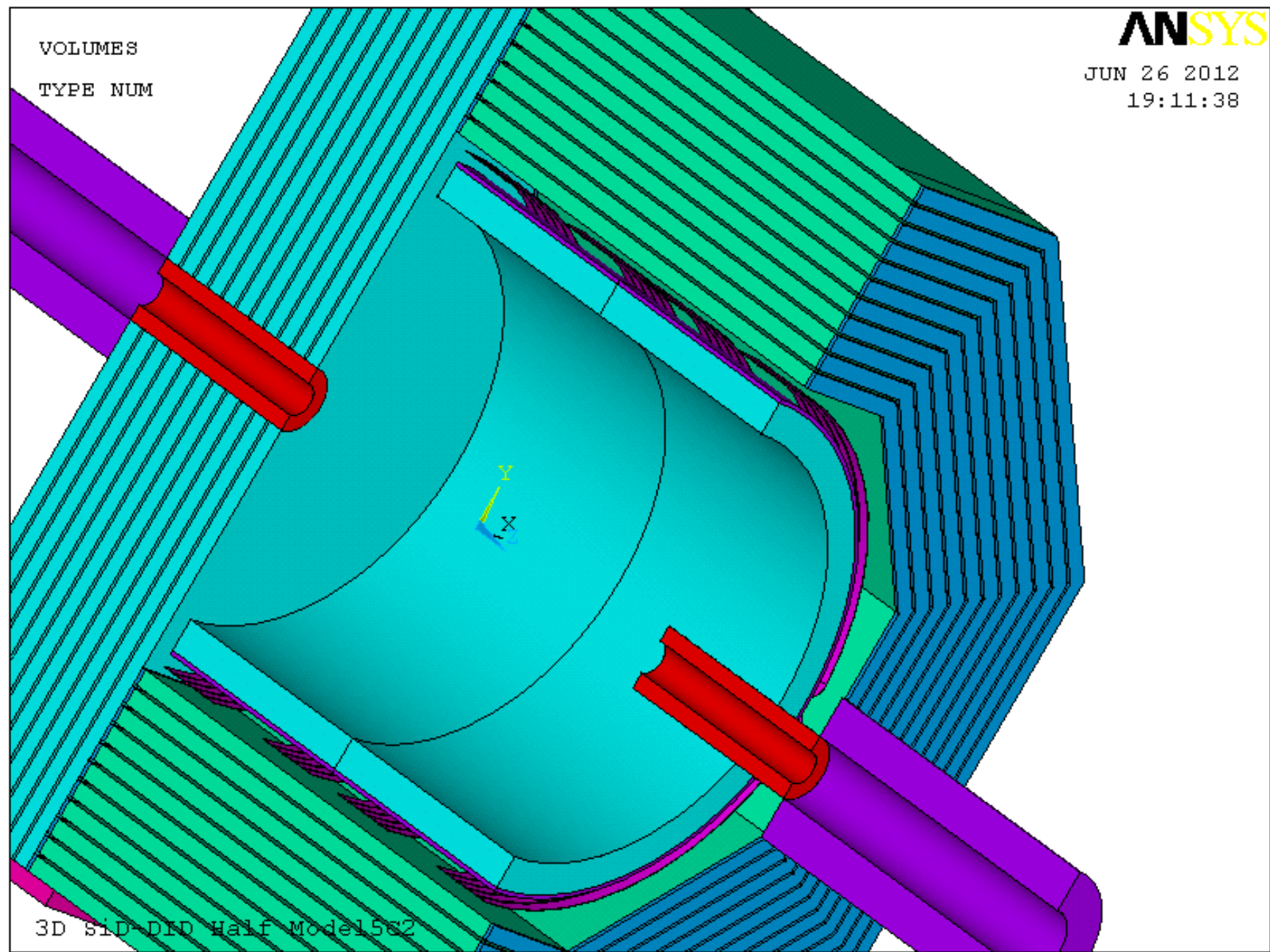


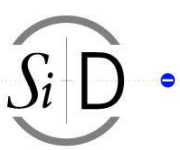
ECFA LC2013
European Linear Collider Workshop
SiD Magnet Overview
SLAC
May 28, 2013
Wes Craddock

VOLUMES
TYPE NUM



3D sld-DTD Half Model1562

Cross Section Showing Current and Iron Volumes



BIG PICTURE --- Comparison to CMS

MAKING LIFE TOO EASY?

- SiD Solenoid Baseline Design uses established CMS conductor/magnet philosophy, technology and experience. (Identical conductor, winding scheme, and stability/safety margins).

EVEN EASIER

- SiD is 1/2 the length of CMS (6 vs. 12 meters & 2 vs. 5 modules)
Assembly of coil, shields, cryostat with ends, and tie rods can be done in the vertical position and then rotated for insertion in the iron.
- SiD stored energy is 1.59 MJ compared 2.69 MJ in CMS

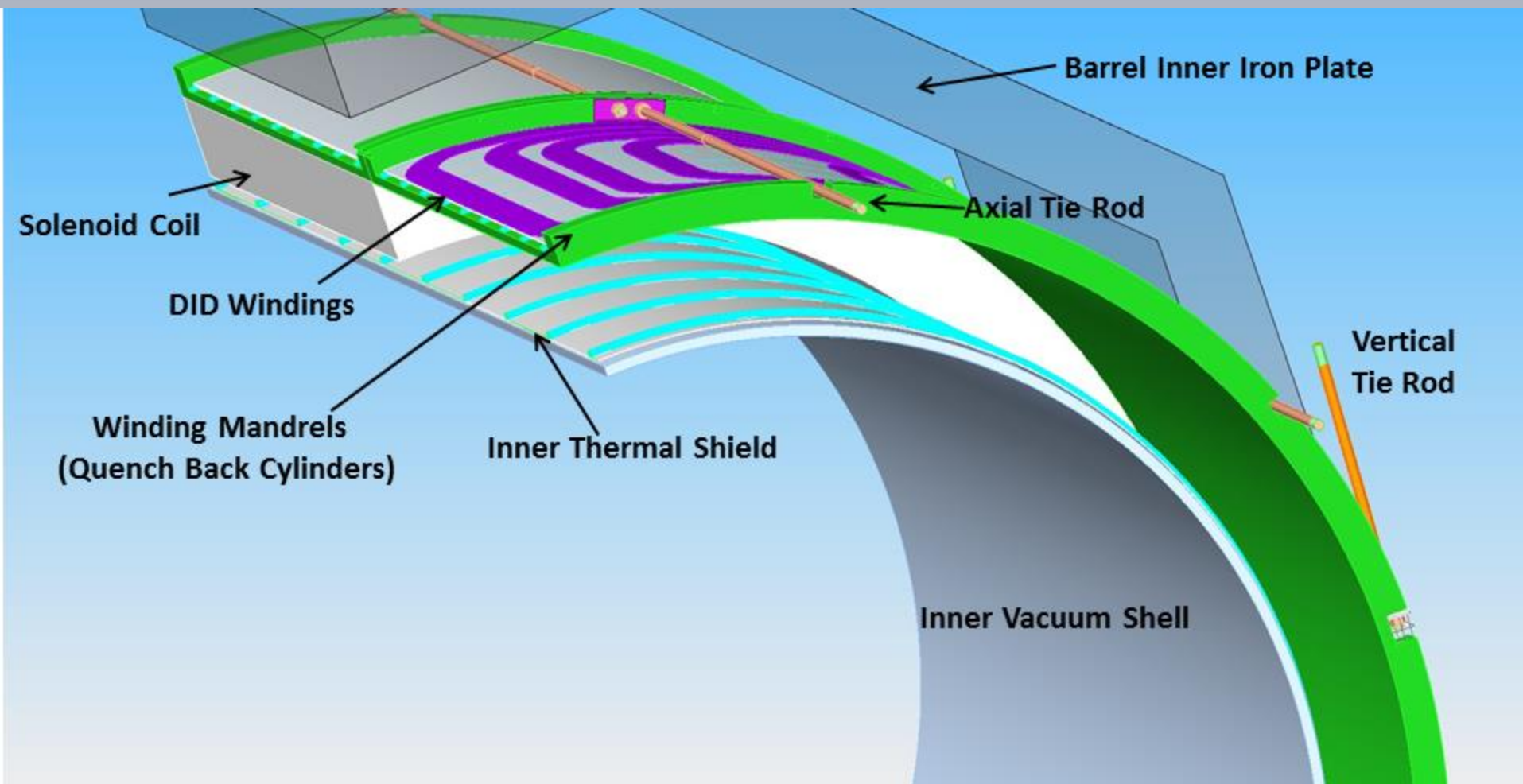
MORE DIFFICULT

- Building and incorporation of a DID coil package into cryostat
- Higher field (5 T vs. 4 T):
 - 1) Greater radial stress
 - 2) 40 strand vs. 32 strand Rutherford cable. Is coextrusion the same?
 - 3) Greater iron saturation and fringe field problems
- 6 Layers vs. 4 layers --- More complex conductor extraction regions
Greater tolerance buildup issues



BIG PICTURE --- What Remains

- **Construction/Integration design of the DID with solenoid or other choice**
- **Integration of the cryogenic system with final focusing magnets
Location of the helium liquefier**
- **Conductor Extraction/Splices details from solenoid center and ends**
- **Magnetics --- A little more iron and improved meshing for ANSYS**
- **Much better cost estimate**
- **Advanced conductor R&D for a better/cheaper solenoid**

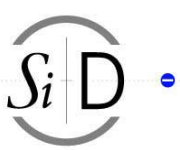


Simplified Magnet Section



DID Coils above the Solenoid

3D SiD-DID Half Model 18



DID COILS (Number 1 Decision)

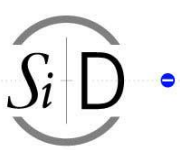
- The DID coil package produces an approximate sinusoidal horizontal 600 G field. It consists of 20 separate coils sandwiched between aluminum plates and attached to the cryostat. Two layers of 2.5 mm tall aluminum stabilized conductor are used. Solenoid coil splices are made above the DID. Solenoid splices could be made first and placed below the DID. However, the baseline choice is thought to be somewhat easier at the present time.
- It appears to be doable within the space allocated for the cryostat.
- The technology is nothing particularly special.

HOWEVER: The practical implementation of carefully and successfully winding and installing this coil system is far from trivial. It will add significant cost, increase the difficulty of solenoid splicing and cryogenic plumbing and perhaps add significant time to the schedule. The coils are very large and flimsy while being handled. Stability criteria must be conservative so that a DID fast dump does not cause a solenoid discharge.

Full current testing would be a major undertaking.

Accurate field calculations are difficult with the DID.

DID coils might be used as a solenoid quench propagator



DID COIL ALTERNATIVES

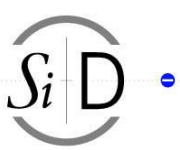
OPTION 1: Is the DID really necessary? --- Cost / Benefit analysis

OPTION 2: Place the field correction elements in the superconducting focusing elements.

SLAC Accelerator Department is committed to > 1 FTE between now and Snowmass to address this issue. Half will be spent on optics and half will be spent on beam – beam effects.

OPTION 3: Mate the two solenoid modules at a small total angle ~ 12 mrad. This will increase the diameter of cryostat by 4 cm.
For all practical purposes this choice is irreversible

OPINION: If Option 2 is possible, this should warrant a serious design study. **Really Think About This.**



What Remains Cryogenic System (Number 2 Decision)

- Two choices are available. The liquefier can be on the detector or the liquefier can be on the hall wall. The current choice is to place the liquefier on the detector.

Liquefier on the Detector --- Flexible compressor suction and return lines

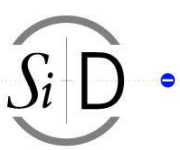
Liquefier on the Wall --- Flexible LHe/Cold Gas return line

Possibility to interconnect SiD & ILD liquefiers

- For either liquefier location, specifics of integration of the cryo system with final focusing magnets is required. The 2 K superfluid final focus magnets need a flexible line running from detector to cavern wall. The vacuum pump must be located away from the detector because of vibration issues.

OTHER --- What Remains

- **Much better cost estimate.** Almost no real costing has been done to date. Costs are based on extrapolation from other magnet systems.
- **Conductor Extraction/Splices details from solenoid center and ends.** The end extraction and splicing of conductor will be more crowded and difficult than CMS since there are 6 layers instead of 4. So far I don't have a 3D CAD layout to prove it can be done. But it seems to be possible.
- **Magnetics --- A little more iron on the outside to reduce fringe fields to 100 G at 1 meter.** Right now they are 200 to 300 G at 1 meter in some areas. More work (meshing) needs to be spent on ANSYS for good convergence. Solution converges very nicely and quickly with linear iron or the DID at 0 amps. Element stiffness ratio is too great.
- **Advanced conductor R&D for a better/cheaper solenoid.** This would be nice but not essential. There are literally dozens of candidates for trying to improve the high purity aluminum.



ABBREVIATED ASSEMBLY SEQUENCE

3. The four DID coil modules are wound on a 3 mm thick Al sheet that is mounted to machined cylinder. Internal coil to coil splices for each of the four modules are completed. A 5 mm sheet is attached to the OD of the DID coils.
4. DID coils are vacuum impregnated.
5. DID coils are mechanically attached on top of solenoid cooling loops with screws to the solenoid mandrel.
8. Solenoid modules are stacked vertical and joined above ground at the detector site.
9. All 24 solenoid splices are completed above the DID. All DID module to module splices are completed.
10. Axial tie rods are attached to the solenoid.
11. Inner and outer thermal shields are mounted to inner and outer vacuum shells.
12. Inner and outer vacuum shells are placed on the solenoid.
13. Vertical and radial tie rods are attached to the outer vacuum shell.
14. All internal plumbing and electrical connections are completed along with mounting of the thermal shield end plates.....
15. Top and bottom vacuum end plates are welded.
17. The completed magnet assembly is rotated horizontal on a shaft parallel to the ground using the overhead crane and two pulling cables.

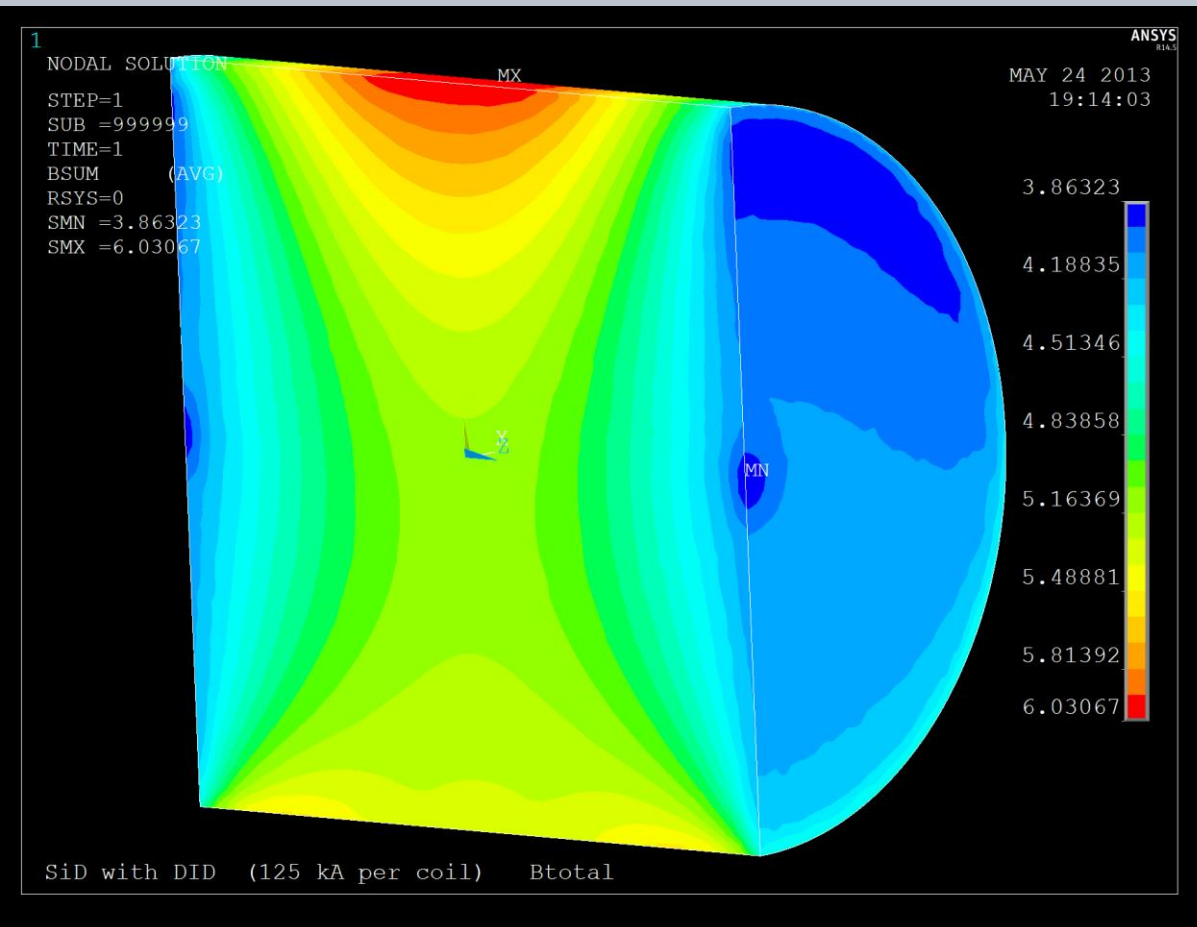


MAGNETICS

Still need some mesh changes for good convergence

Problem is the small 5 mm radial thickness of the DID coils

Element stiffness ratio between the DID region and the very low B field portions of PacMan iron



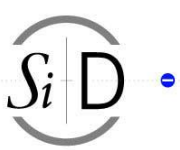
ANSYS – Edge Elements

6.7 million elements

9.5 million nodes

64 GB PC still runs out of core

Will be able to calculate total stored energy later this year with release of ANSYS 15



CONDUCTOR R&D

OTHER POSSIBLE TECHNOLOGIES

- Conklad extrusion process --- Friction generated heat from spinning wheels feeding wire

Is anything better (practical) than Al-0.1% Ni ?

- Other aluminum micro alloys using cerium, yttrium, scandium
- Aluminum core shell micro alloy precipitates such as Al-Zr-Sc
- Candidate reinforcing nanoparticles include SiC, Al₂O₃, TiC, BN, AlB₂, AlN, B₄C, AlB₂O₃, and TiB₂.
- Carbon nanotubes seem difficult to incorporate. No confirmation (LLNL or others) of one report showing a sudden drop in resistivity at 75 K.

.



CONCLUSIONS

AREAS FOR SIGNIFICANT WORK

- **IMPROVED COST ESTIMATE**
- **DID CHOICE AND DESIGN IF INCORPORATED WITH SOLENOID**
- **INTEGRATED CRYOGENICS SYSTEM**
- **SOME SPECIFIC DETAILS SUCH AS CONDUCTOR SPLICE REGION**
- **CONDUCTOR R&D AS MONEY, PEOPLE AND TIME PERMIT**
- **MORE 3D CAD MODELLING OF DETAILS**